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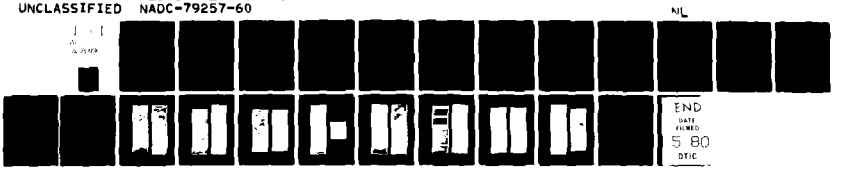

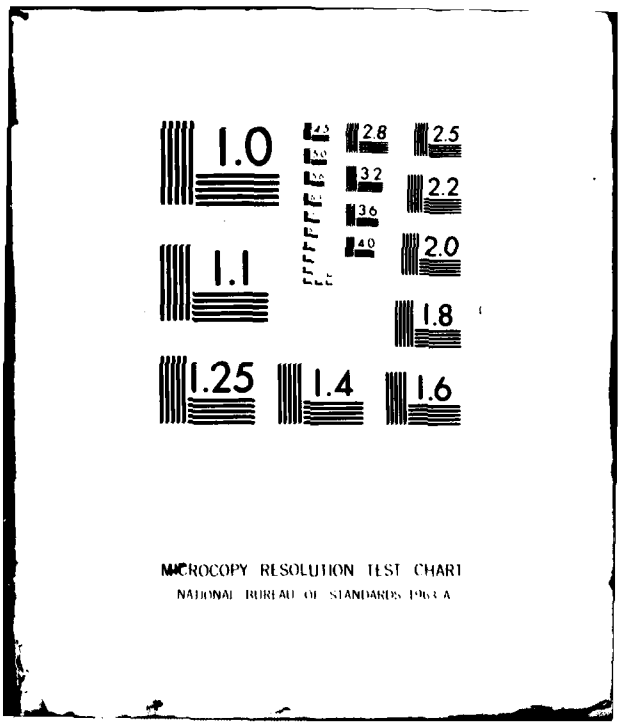
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SALT SPRAY TESTING OF METALLIC - CERAMIC COATINGS

E. J. Jankowsky
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8 February 1980

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AIRTASK NO. A510-5102/001-D/9W0625-0000
F-18 Materials Technology Support

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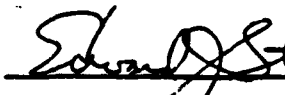
APPROVED BY:  DATE: 2/8/80

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Fifteen metallic-ceramic coatings consisting of aluminum or aluminum-magnesium pigment suspended in an inorganic binder were applied to steel panels and tested for corrosion resistance in SO_2-salt fog and 5% salt fog, respectively. Four coatings offered better protection than the MIL-C-81751 coating (Sermetel W). The best coating was Sermetel 762. Sermetel 763, Sermatel 725, and a dual coating of Sermetel W, Class 4 over Class 2, followed in order of decreasing protection.

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S U M M A R Y

INTRODUCTION

This investigation was conducted under reference (a) for the purpose of determining the corrosion resistance of several new Sermetel coatings that might be useful for protecting steel aircraft components.

Sermetel W is a metallic-ceramic type coating containing aluminum powder in an inorganic, chromate-phosphate binder. It meets the requirements of MIL-C-81751 and has been used successfully for many years for the corrosion protection of various components in naval aircraft.

The new coatings are based on the same concept of metallic pigment suspended in an inorganic binder material. All the coatings tested in this investigation contained either all aluminum pigments or combinations of aluminum and aluminum-magnesium alloy. In some cases, an overcoating of a chromate inhibited sealer coating (Sermetel 570A) was used to improve corrosion resistance. The coatings were applied by spraying followed by curing at temperatures ranging from 204°C (400°F) to 566°C (1050°F).

Fifteen coatings were evaluated for protective value on steel in both 5% salt fog and SO_2 salt fog.

SUMMARY OF RESULTS

Results of corrosion tests indicate that the best Sermetel W coating is Class 4 which is cured at 343°C (650°F) for 1/2 hour followed by burnishing with glass beads. Class 2 was next and Class 1 was a poor third. Four of the new coatings offered better protection than Sermetel W, Class 4. In order of decreasing protection, they were: Sermetel 762, Sermetel 763, Sermetel 725, and a dual coating of Sermetel W, Class 4 over Class 2. The remaining coatings were all equal to or poorer than W, Class 4.

Several coatings survived the 1056 hour 5% salt fog exposure test, but all except one panel of one coating failed within 456 hours of SO_2 - salt fog testing.

CONCLUSIONS

Sermetel 762 and 763 are the best of the coatings tested for the protection of steel against corrosion.

Sermetel 725 is the best low temperature cure coating (343°C).

Class 4 (glass bead burnished) is the most corrosion resistant of the MIL-C-81751 classes.

The lowest curing temperature (204°C) results in coatings with the poorest corrosion resistance.

Sermetel 735 was the better of the two thin coatings (20 mm) tested.

RECOMMENDATIONS

1. It is recommended that consideration be given to the use of Sermetel 763, 762, and 725 for the protection of steel components against corrosion where tempering temperatures are higher than the required curing temperatures.

2. It is recommended that testing of the best systems be extended to determine whether they meet all the requirements of MIL-C-81751.

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Cadmium has been used extensively for the protection of steel aircraft parts against corrosion. Recently, the Environmental Protection Agency has requested the Department of Defense to eliminate cadmium from any application for which an alternate coating can be used. It was felt that some of the new Sermetel coatings might be used in some applications. Their greatest shortcoming, as far as general use is concerned, is the high curing temperature required. It was for this reason that lower curing temperatures for longer times were tried with some of the coatings. Additionally, Teleflex, Inc., manufacturer of the Sermetel coatings, has conducted a great deal of research work to improve their basic Sermetel W process. Among these improvements is a clear, corrosion inhibited sealer coat applied over the aluminum pigmented coat. Modifications have also been made in the pigment systems.

One application directly related to the F-18 is the inside of the landing gear. Ion vapor deposited aluminum is difficult to coat in this area and cadmium plating poses some danger of hydrogen embrittlement. If the curing temperature could be kept below 302°C (575°F), the tempering temperature of the 300 M steel in the landing gear, then one of the Sermetel coatings could be used. In other areas, where the tempering temperature is higher, some of the other Sermetels might serve.

This investigation was undertaken at the request of the Naval Air Systems Command (AIR-5163C2).

It should be noted that no attempt was made to determine the elevated temperature properties of the coatings.

T E S T M E T H O D S

SPECIMENS

Specimens consisted of 5 x 10.2 x 0.32 cm (2" x 4" x 1/8") panels of AISI 1020 steel coated with the various systems by the Sermetel Division of Teleflex, Inc. Coating systems are listed in Table I. All the coatings except 622 are aluminum filled chromate/phosphate dispersions in a water base. Sermetel 622 is an aluminum and aluminum magnesium filled chromate/phosphate dispersion. All are sacrificial to steel (provide galvanic protection) except Sermetel W, Class 1 which acts only as a barrier against the corrosive environment. SermaSeal 570A is a chromate-based topcoat sealer without any pigment.

TABLE I. LIST OF SPECIMENS

Specimen	Sermetel Coating Identification	Cure Temperature (°F) & Time (Hrs.)	Description or Remarks	Nominal Thickness mm (mils)
1 to 6	W Class 1	204°C (400°F) - 24 Hours	Low temperature cure of Sermetel W.	63 (2.5)
7 to 12	W Class 1	343°C (650°F) - 1/2 Hour	Standard.	63 (2.5)
13 to 18	W Class 2	566°C (1,050°F) - 1/2 Hour	Standard.	63 (2.5)
19 to 24	754	204°C (400°F) - 2 Hours	Low temperature modified W.	63 (2.5)
25 to 30	W Class	343°C (650°F) - 1/2 Hour	Bead burnished.	63 (2.5)
31 to 34	W Class 2 & W Class 4	566°C (1,050°F) - 1/2 Hour	Burnished (Beads).	63 (2.5)
35 to 40	759	204°C (400°F) - 2 Hours	Modified 735 System.	20 (0.8)
41 to 46	735	343°C (650°F) - 1/2 Hour		20 (0.8)
47 to 50	717	566°C (1,050°F) - 1/2 Hour		20 (0.8)
51 to 56	758	204°C (400°F) - 2 Hours	Modified 725 System.	63 (2.5)
57 to 62	725	343°C (650°F) - 1/2 Hour		63 (2.5)
63 to 66	763	566°C (1,050°F) - 1/2 Hour	W Class 2 and topcoat @ 650.	71 (2.8)
67 to 72	761	204°C (400°F) - 2 Hours	Modified 622 and 570A for low curing.	84 (3.3)
73 to 78	762	427°C (800°F) - 1/2 Hour 343°C (650°F) - 1/2 Hour	One coat 622 cure 800°F + W. Class 1 + 570A - 650°F.	84 (3.3)
79 to 82	622	427°C (800°F) - 1/2 Hour	Modified cure to 800°F for greatest action.	76 (3.0)

5% SALT SPRAY

Half of the panels were exposed to 5% salt fog in 15 degree racks in accordance with ASTM B-117. All panels were scribed with an X through the coating prior to exposure. Panels were examined every day for signs of rust in the scribes. Testing was discontinued after 1056 hours.

SO_2-SALT SPRAY

The remaining panels were scribed and exposed to SO_2-salt spray in 15 degree racks. In this test, sulfur dioxide gas is introduced into the 5% salt fog box for one hour four times every 24 hours. Reference (b) gives a detailed description. The test is much more severe than the standard salt fog test and is considered to simulate a carrier deck environment more closely. The panels in SO_2-salt spray were also examined daily for signs of rust in the scribes. The first sign of rust was considered failure. The first panel to fail in the series was used for failure times given in the results section.

R E S U L T S

5% SALT SPRAY TESTS

Results of salt spray tests are given in Table II and shown in Figures 1 through through 5. Although the first rust in any of the scribes was taken as the failure time for the series, there was considerable difference in the overall appearance of the panels at failure. It is for this reason that Figures 2 to 5 were taken. It is obvious from the photographs that some of the systems failed only in the scribes, while others showed general corrosion on the panel faces as well. Testing was discontinued after 1056 hours of exposure. The following coatings showed no rust in the scribes at the end of the test:

W Class 2, 566°C - 1/2 hour cure
W Class 4, 343°C - 1/2 hour cure
W Class 2 and W Class 4, 566°C - 1/2 hour cure
735, 343°C - 1/2 hour cure
758, 204°C - 1/2 hour cure
763, 566°C - 1/2 hour cure
761, 204°C - 1/2 hour cure
762, 427°C - 1/2 hour, 343°C - 1/2 hour cure
622, 427°C - 1/2 hour cure

Two of the coatings, 754 and 761, had considerable rust on their faces at the end of the test. The 754 coating failed in the scribes in 120 hours, but the 761 coating was unusual in that there was no rust in the scribes at the end of the 1056 hour test period, only rust on the faces. The 758 coating had rust only on the edge of one scribe, but considerable white corrosion over all the panels at 1056 hours. The 725 coating had excellent overall appearance. A few tiny rust spots appeared in the scribes of one panel after 1056 hours, otherwise this coating would have been among those passing. In overall appearance, it was better than 735.

SO_2-SALT SPRAY TESTS

Results of SO_2-salt spray tests are given in Table II and shown in Figures 1 and 6 to 9. None of the coating systems tested withstood more than 456 hours of testing without rusting in the scribes. All of the coatings showed signs of rusting on their faces at the time they failed in the scribes, except those that failed in the scribes after very short exposure. Coating 754 blistered in 24 hours. The best coatings in this test were 762 and 763, both failing after 456 hours. 725 was next with failure time of 360 hours. Of the two thin coatings tested, 717 and 735, 735 was the better.

C O N C L U S I O N S

Sermetel 762 and 763 are the best of the coatings tested for the protection of steel against corrosion.

Sermetel 725 is the best low temperature cure coating (343°C).

Class 4 (glass bead burnished) is the most corrosion resistant of the MIL-C-81751 classes.

Sermetel 735 is the better of the two thin (20 mm) coatings tested.

Low temperature (204°C) cures generally result in coatings that offer poorer protection than higher temperature cures.

SO_2-Salt spray is much more corrosive to coatings of the Sermetel type than standard 5% salt spray.

R E F E R E N C E S

(a) AIRTASK No. A510-5102/001-D/9W0625-0000, F-18 Materials Technology Support of 9 Nov 1978

(b) Naval Air Development Center Report No. NADC-77252-30, Accelerated Laboratory Corrosion Test for Materials and Finishes used in Naval Aircraft, 14 Sep 1977

TABLE II. SERMETEL COATINGS ON 1020 STEEL, EXPOSURE TEST RESULTS

Coating Identification	Cure Temperature and Time	Time to Failure (hours)- SO_2 Salt Spray *	Time to Failure (hours)- 5% Salt Spray *
W, Class 1	204°C - 24 hours	24	24
W, Class 1	343°C - 1/2 hour	24	24
W, Class 2	566°C - 1/2 hour	120	1056 **
754	204°C - 2 hours	24	120
W, Class 4	343°C - 1/2 hour	192	1056 **
W, Class 2 & W, Class 4	566°C - 1/2 hour	216	1056 **
759	204°C - 2 hours	24	24
735	343°C - 1/2 hour	192	1056 **
717	566°C - 1/2 hour	96	120
758	204°C - 2 hours	24	1056
725	343°C - 1/2 hour	360	1056
763	566°C - 1/2 hour	456	1056 **
761	204°C - 2 hours	96	1056 **
762	427°C - 1/2 hour 343°C - 1/2 hour	456	1056 **
622	427°C - 1/2 hour	96	1056 **

* First failure of the panel series.
First sign of rust in the scribe marks.

** Did not fail - tests discontinued.

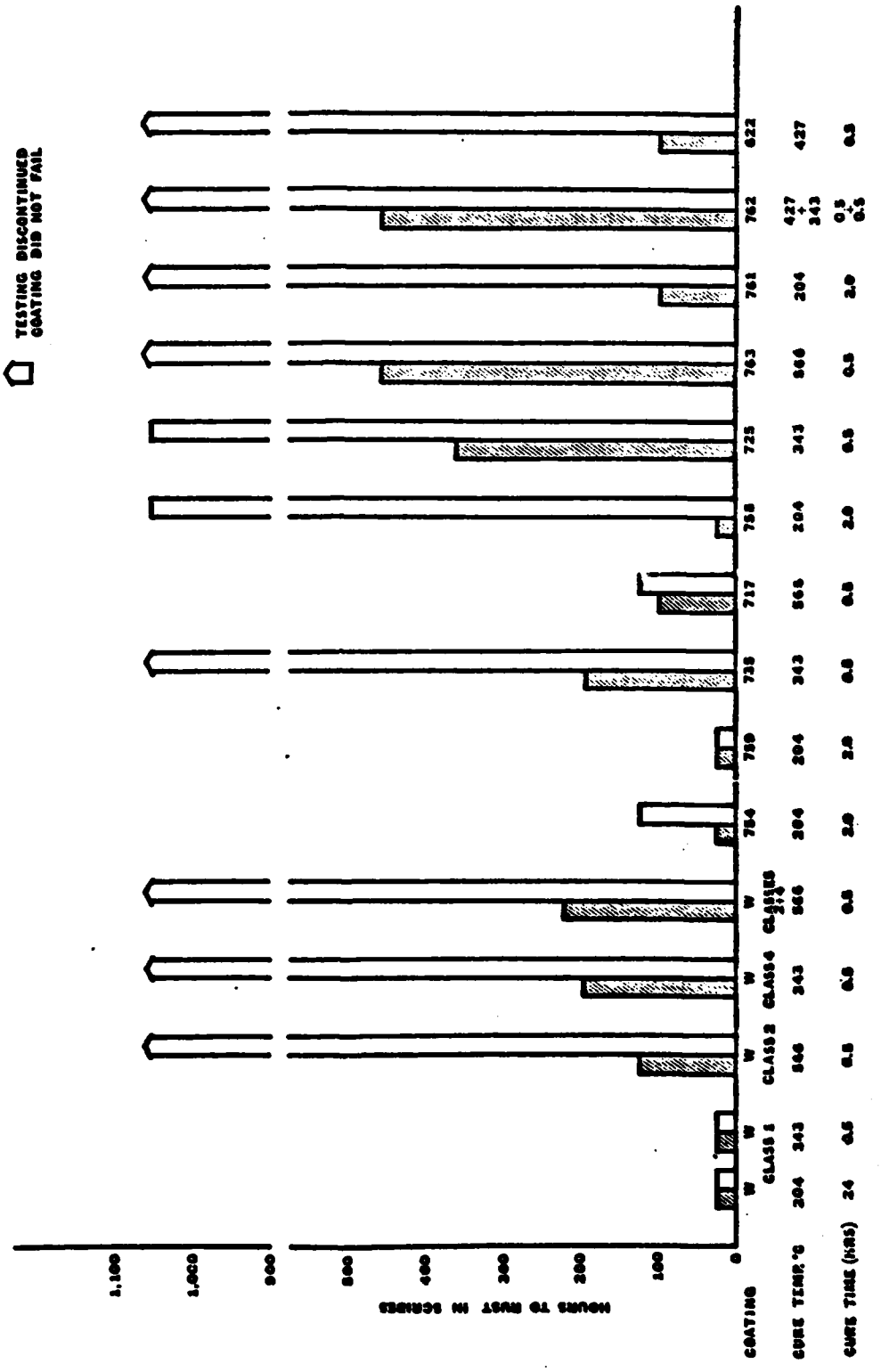


FIGURE 1. SALT SPRAY EXPOSURE FAILURE TIMES - SERMETEL COATINGS

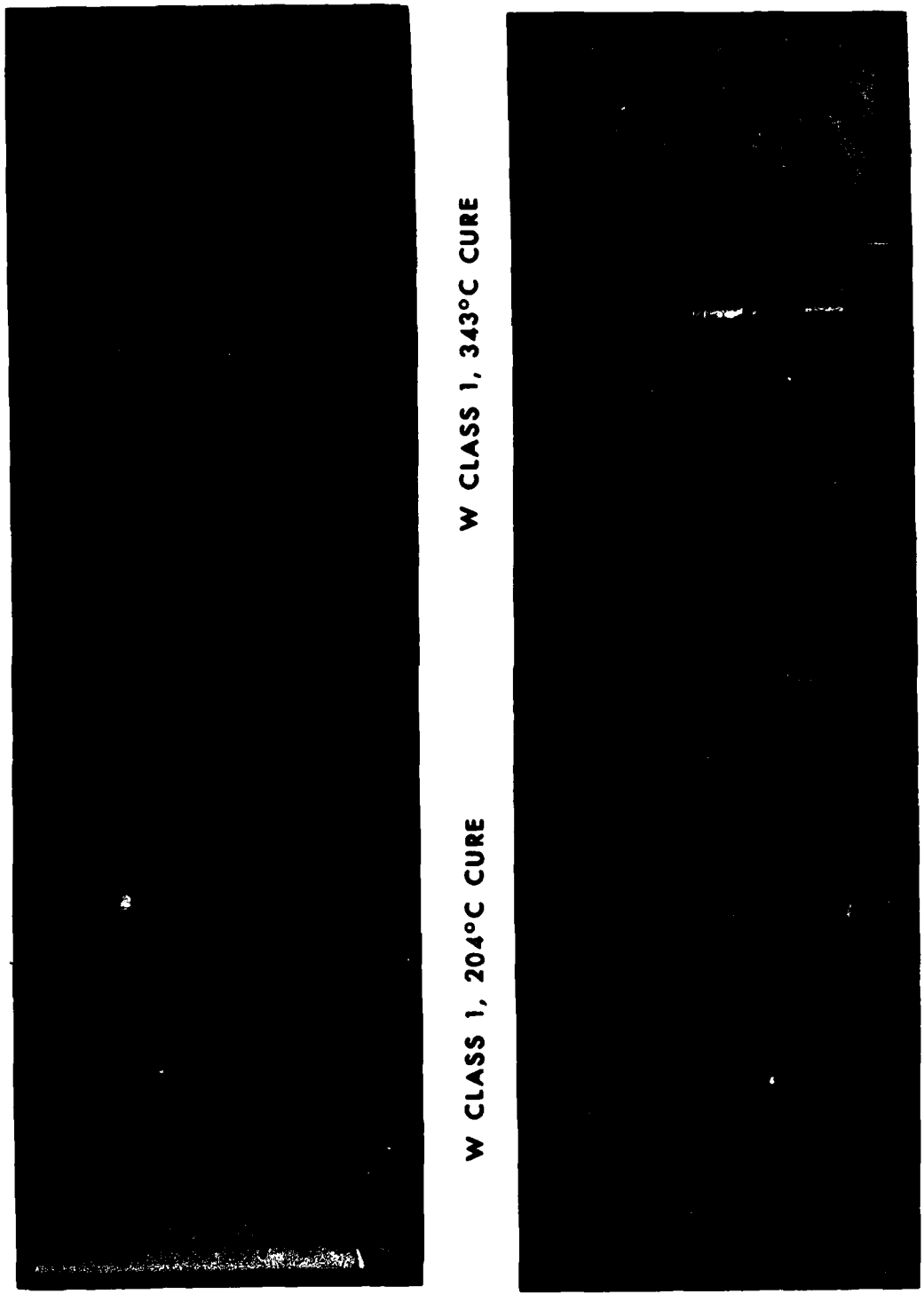
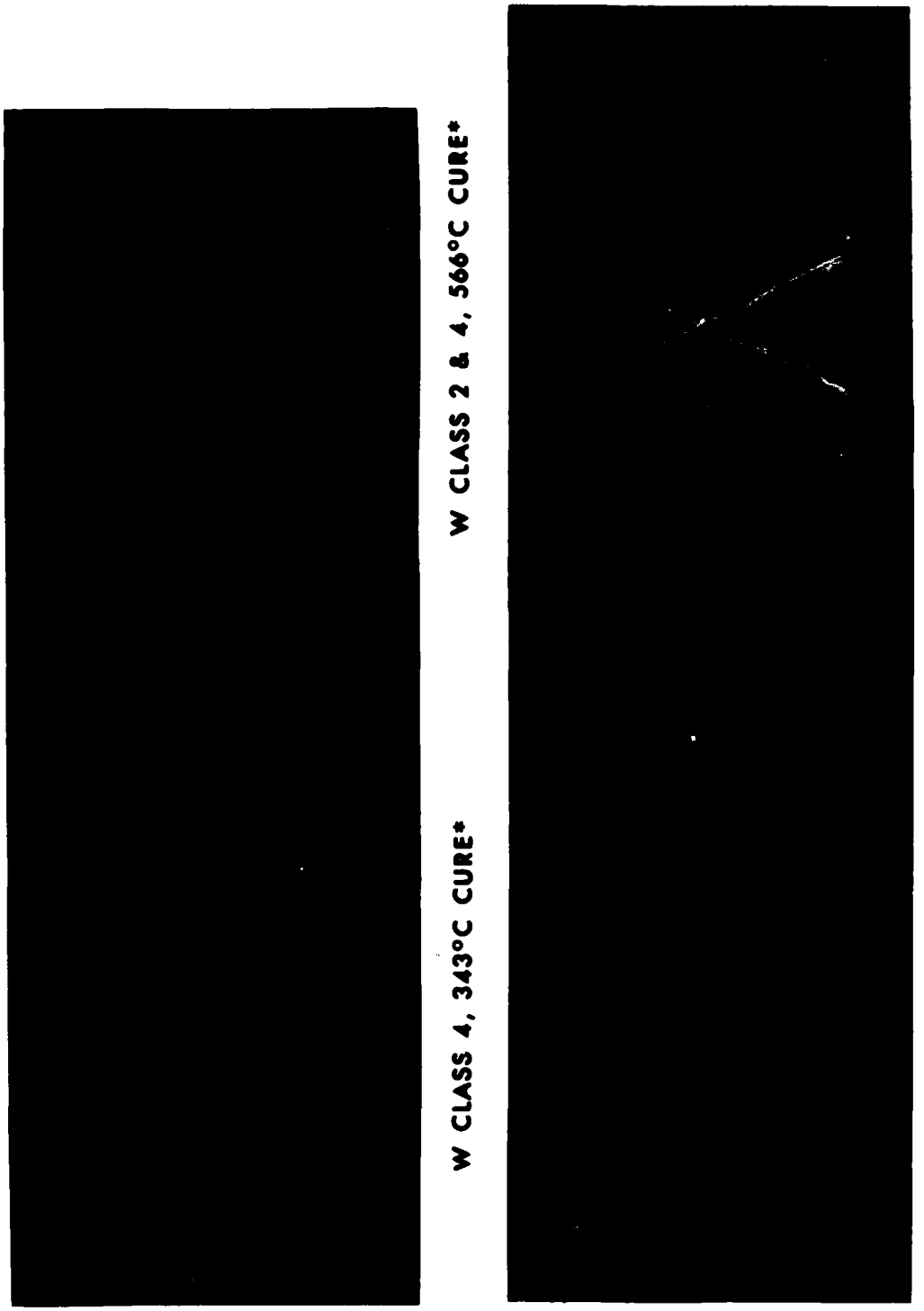
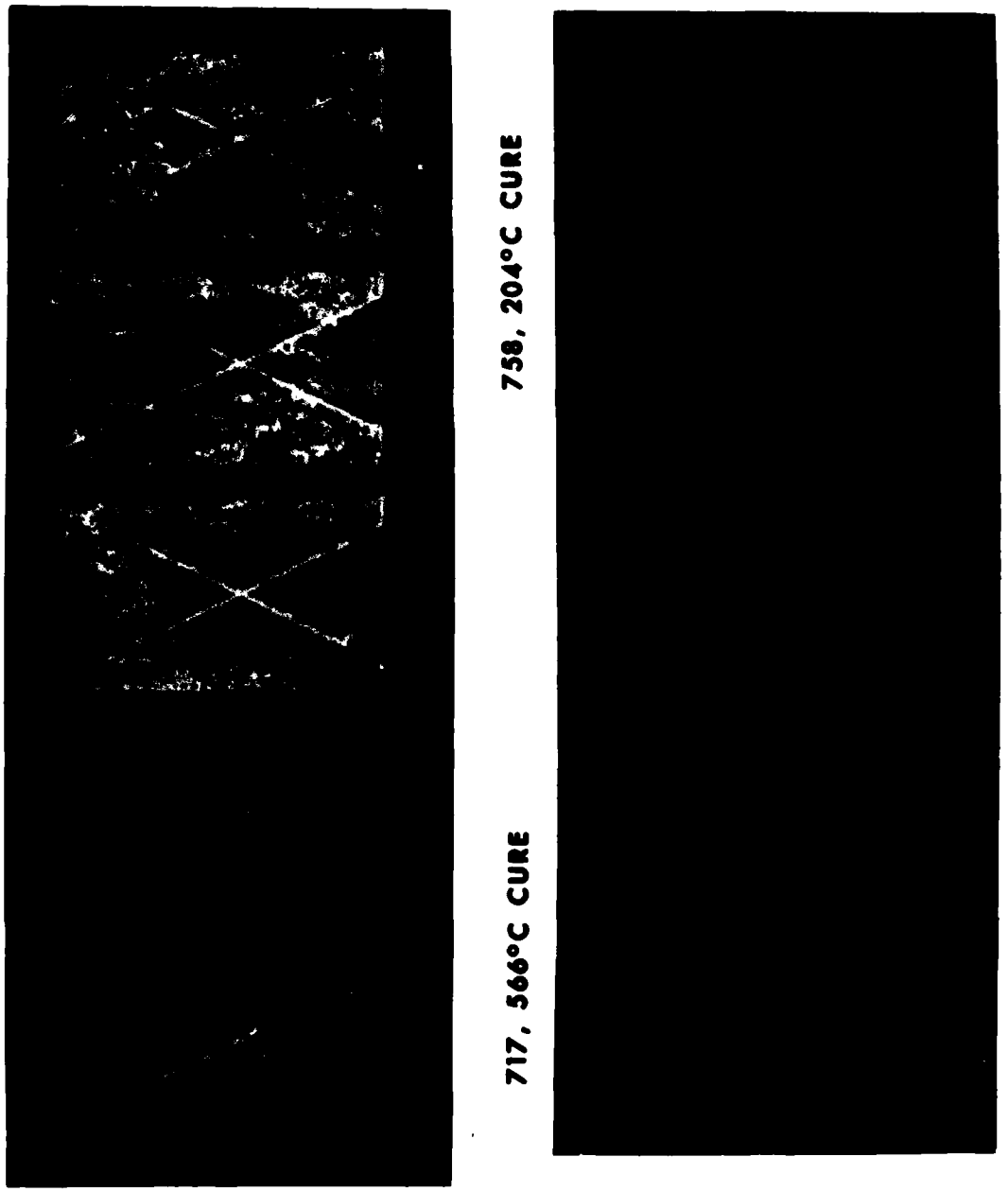

W CLASS 1, 204°C CURE
W CLASS 1, 343°C CURE
W CLASS 2, 566°C CURE*
754, 204°C CURE
APPEARANCE OF SERMETEL COATINGS AT FAILURE - 5% SALT SPRAY

FIGURE 2



APPEARANCE OF SERMETEL COATINGS AT FAILURE - 5% SALT SPRAY

FIGURE 3



717, 566°C CURE

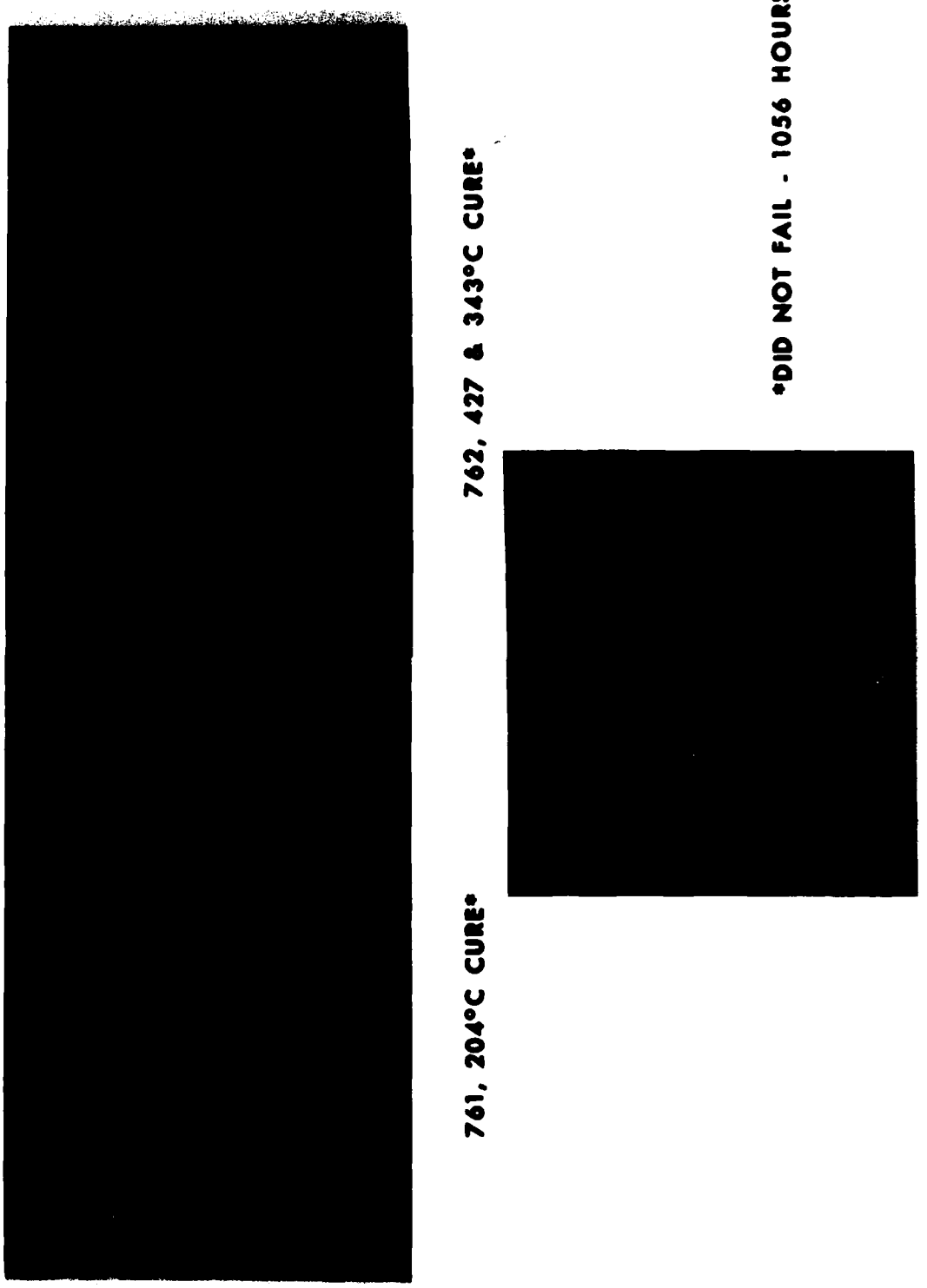
758, 204°C CURE

725, 343°C CURE

763, 566°C CURE *

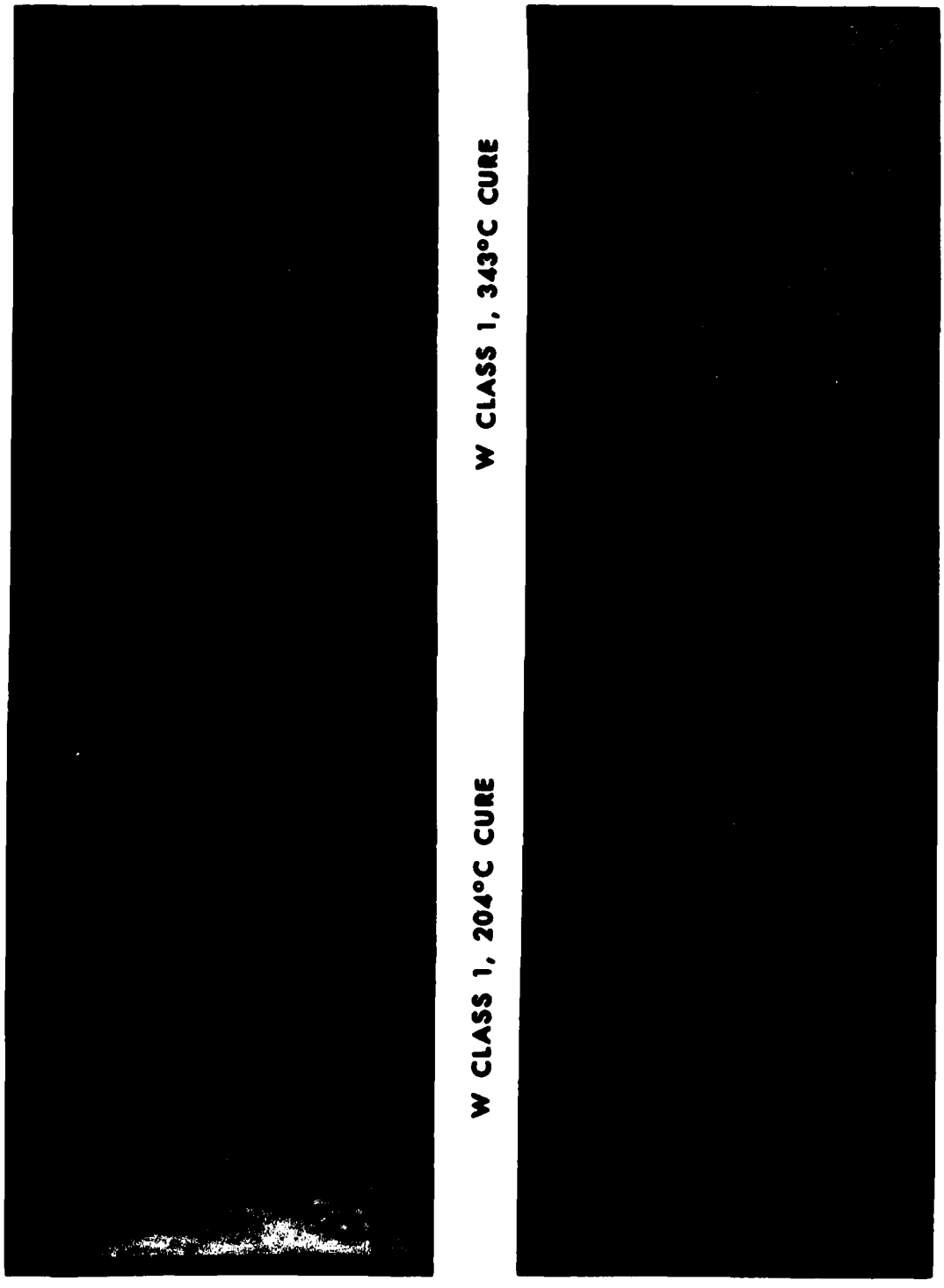
APPEARANCE OF SERMETEL COATINGS AT FAILURE - 5% SALT SPRAY

FIGURE 4



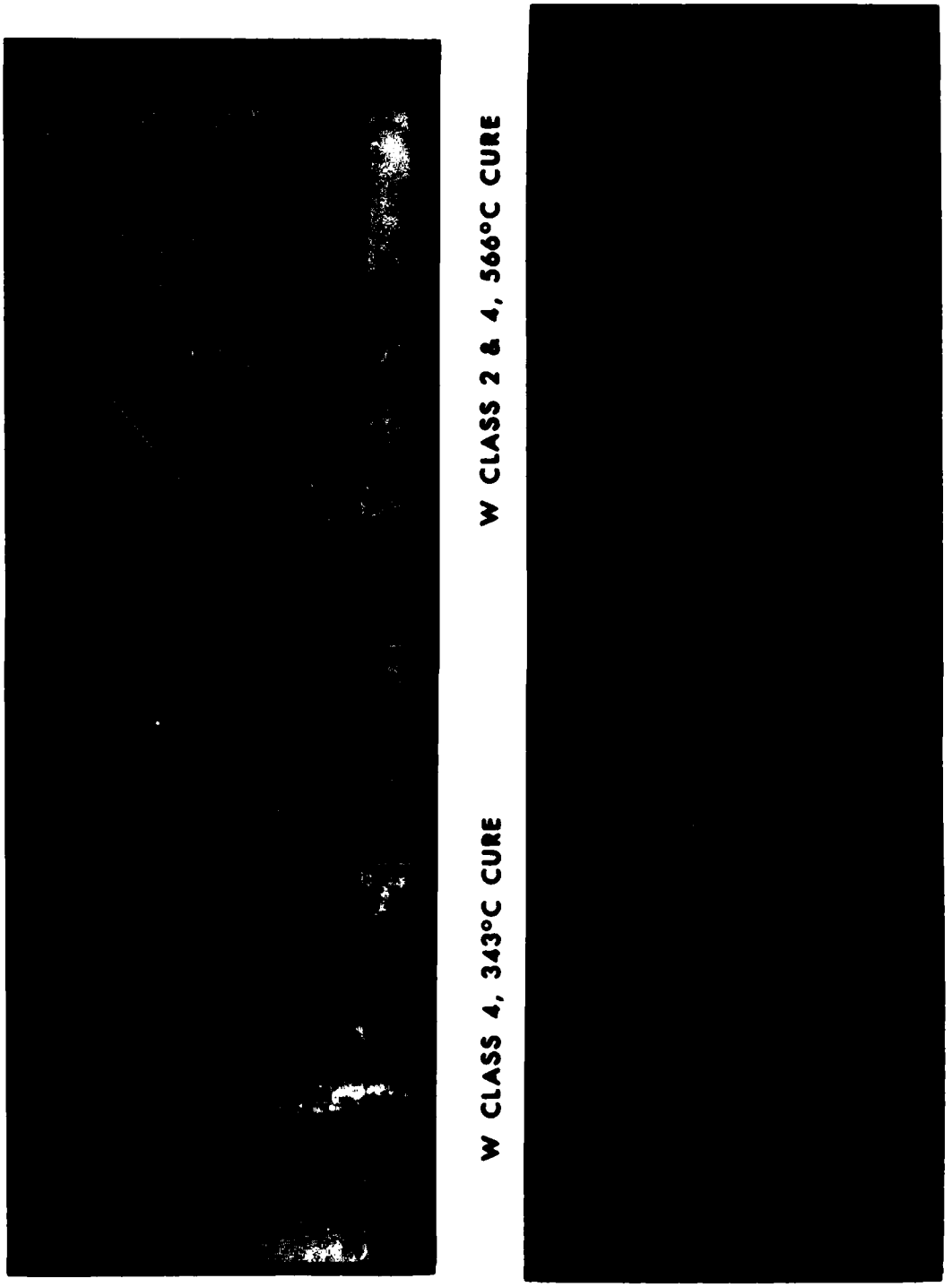
APPEARANCE OF SERMETEL COATINGS AT FAILURE - 5% SALT SPRAY

FIGURE 5



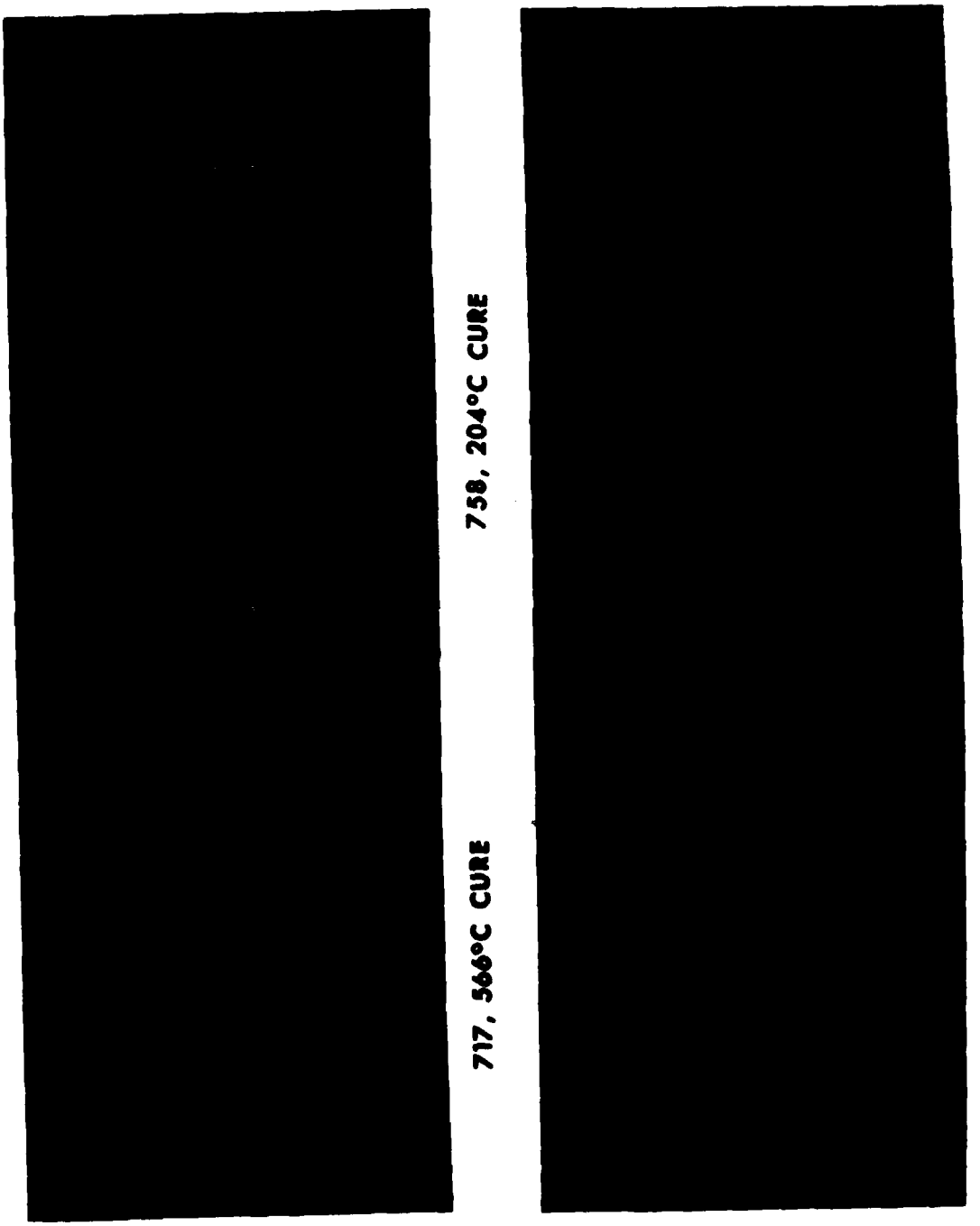
APPEARANCE OF SERMETEL COATINGS AT FAILURE - SO_2 SALT SPRAY

FIGURE 6



APPEARANCE OF SERMETEL COATINGS AT FAILURE - SO_2 SALT SPRAY

FIGURE 7



717, 566°C CURE

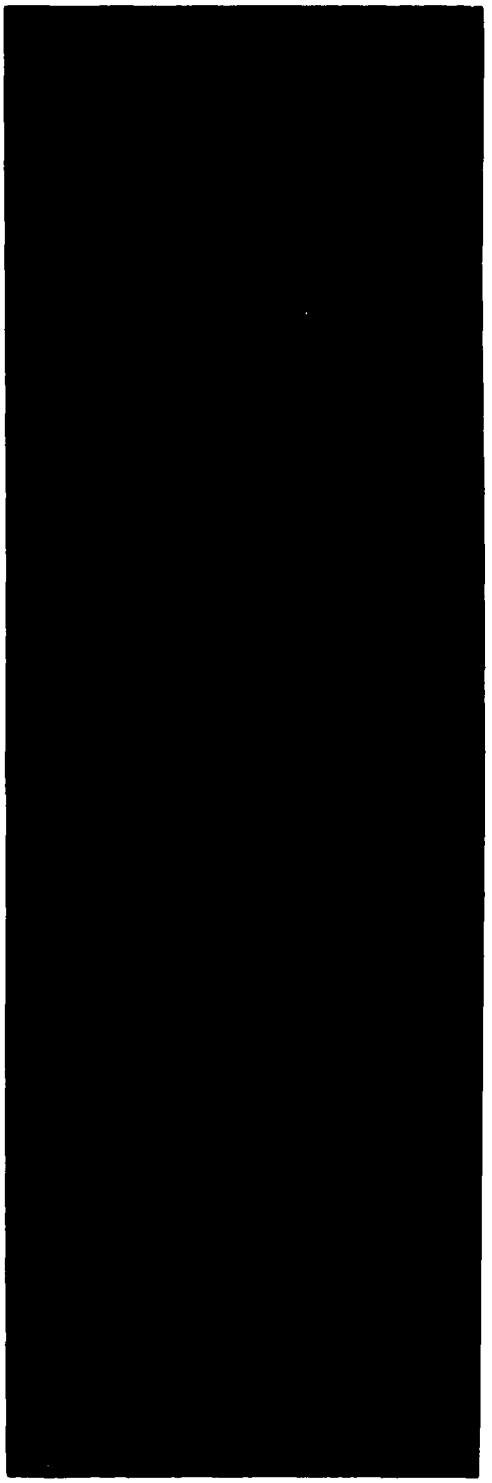
758, 204°C CURE

725, 343°C CURE

763, 566°C CURE

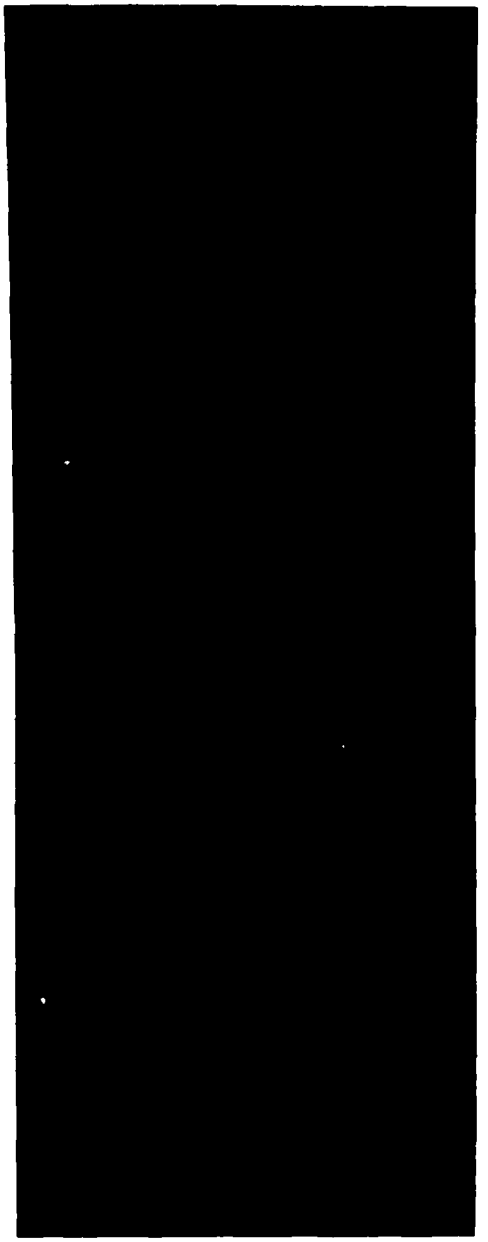
APPEARANCE OF SERMETEL COATINGS AT FAILURE - SO_2 SALT SPRAY

FIGURE 8



761, 204°C CURE

762, 427 & 343°C CURE



622, 427°C CURE

APPEARANCE OF SERMETEL COATINGS AT FAILURE - SO_2 SALT SPRAY

FIGURE 9

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